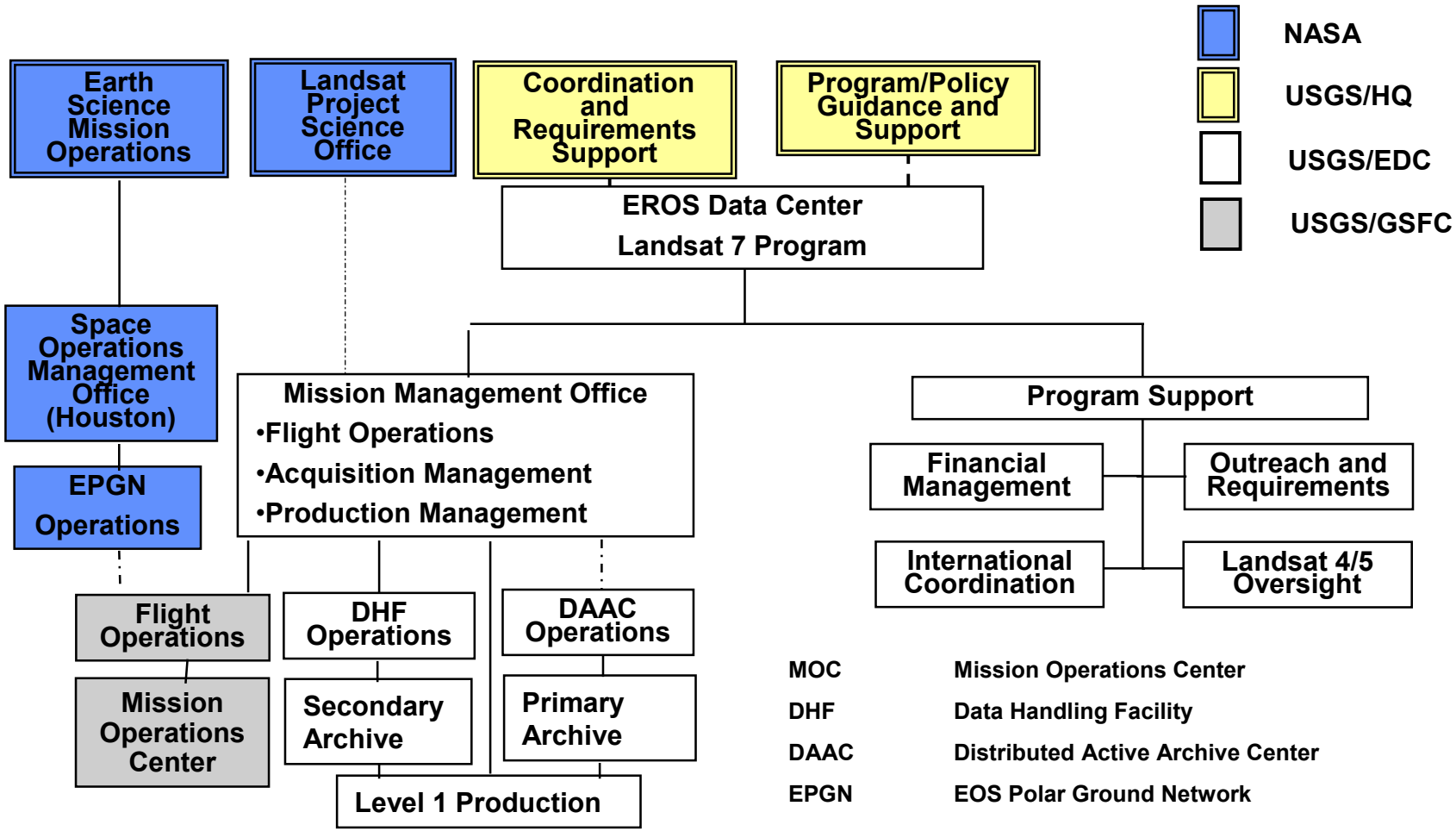
Landsat 7 Program Status

U.S. Department of the Interior
U.S. Geological Survey

Landsat 7 Program Management



Mission Status

- All spacecraft elements are operating nominally, except for:
  - SSR PWA # 23 (no impact on mission capability)
  - SSR PWA # 12 (~ 5% impact on recorder capability)
- Landsat 7 Science Team rates ETM+ data and associated products as high quality
- Ground data processing, archiving, and product generation systems are fully operational

Mission Status

Operating Constraints

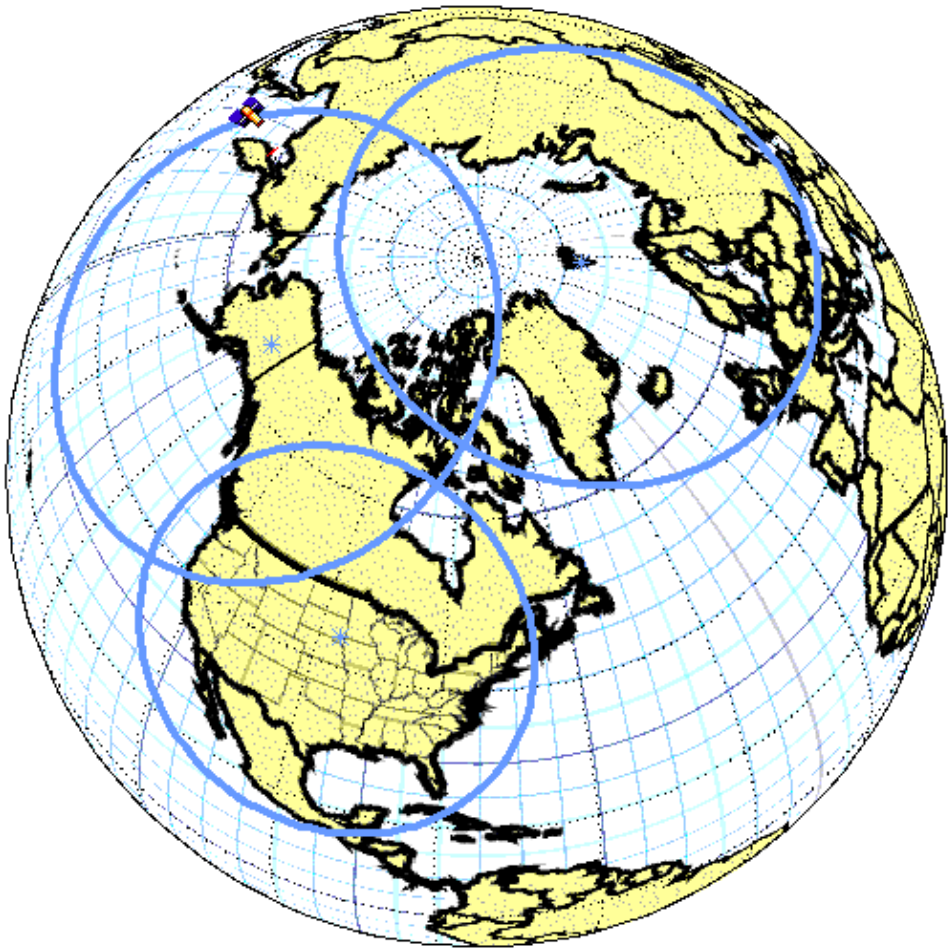
- Instrument duty cycle (16.7 % overall)
- Three gimbaled X-band directional antennae
- Solid State Recorder capacity management
- Ground Data System ingest capacity
- Special requests require MMO intervention
- Acquisition management is a complex process

Transition Activities

Mission Operations Center

- Full-service contract for FOT services executed effective 11/16/00
- Incident reporting procedure implemented to ensure notification of key USGS/NASA personnel regarding anomaly events.
- Implemented Mission Operations Center (MOC) Configuration Control Board
- Implemented a Landsat 7 Configuration Control Board.

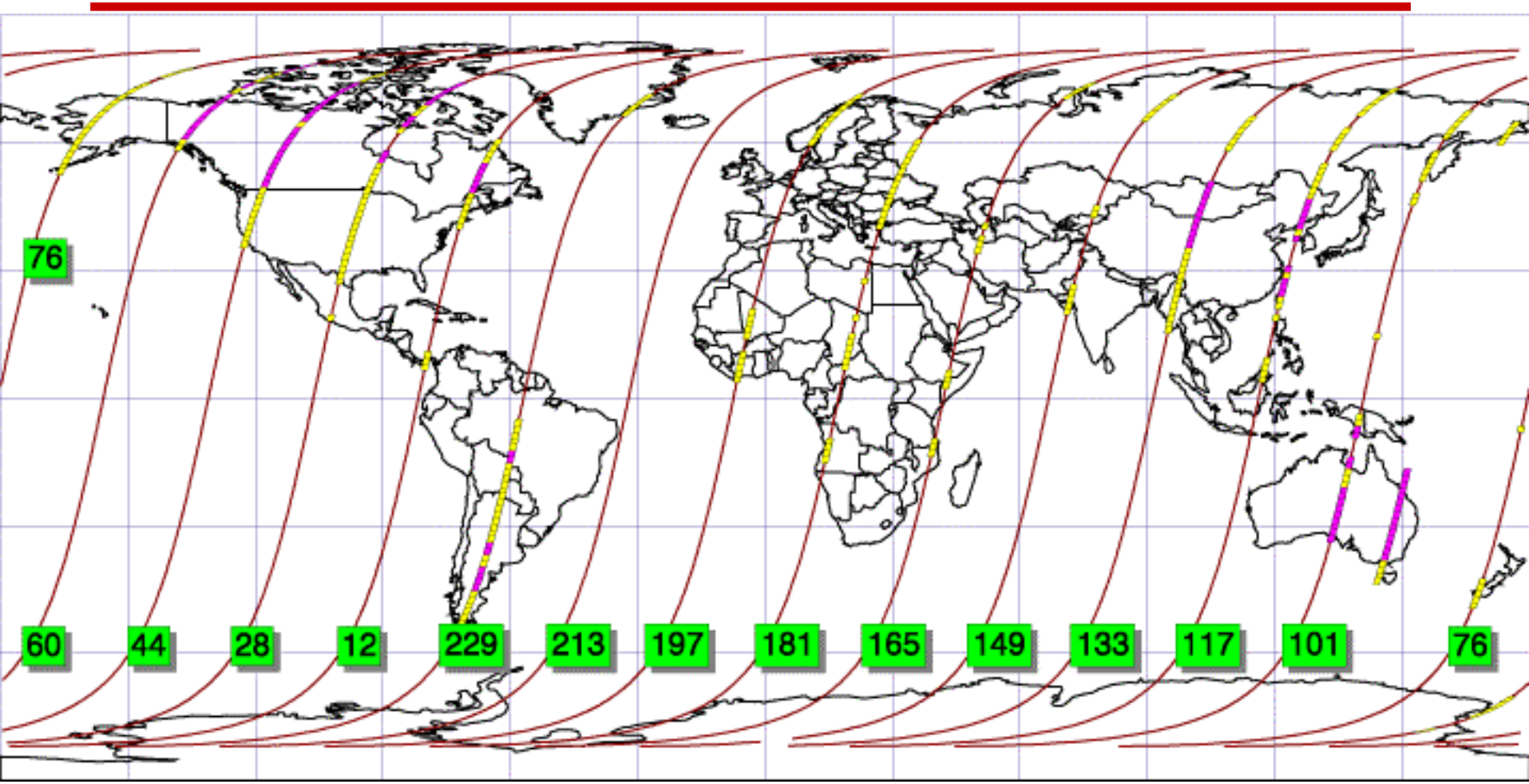
Data Acquisition



U.S. Receiving Stations

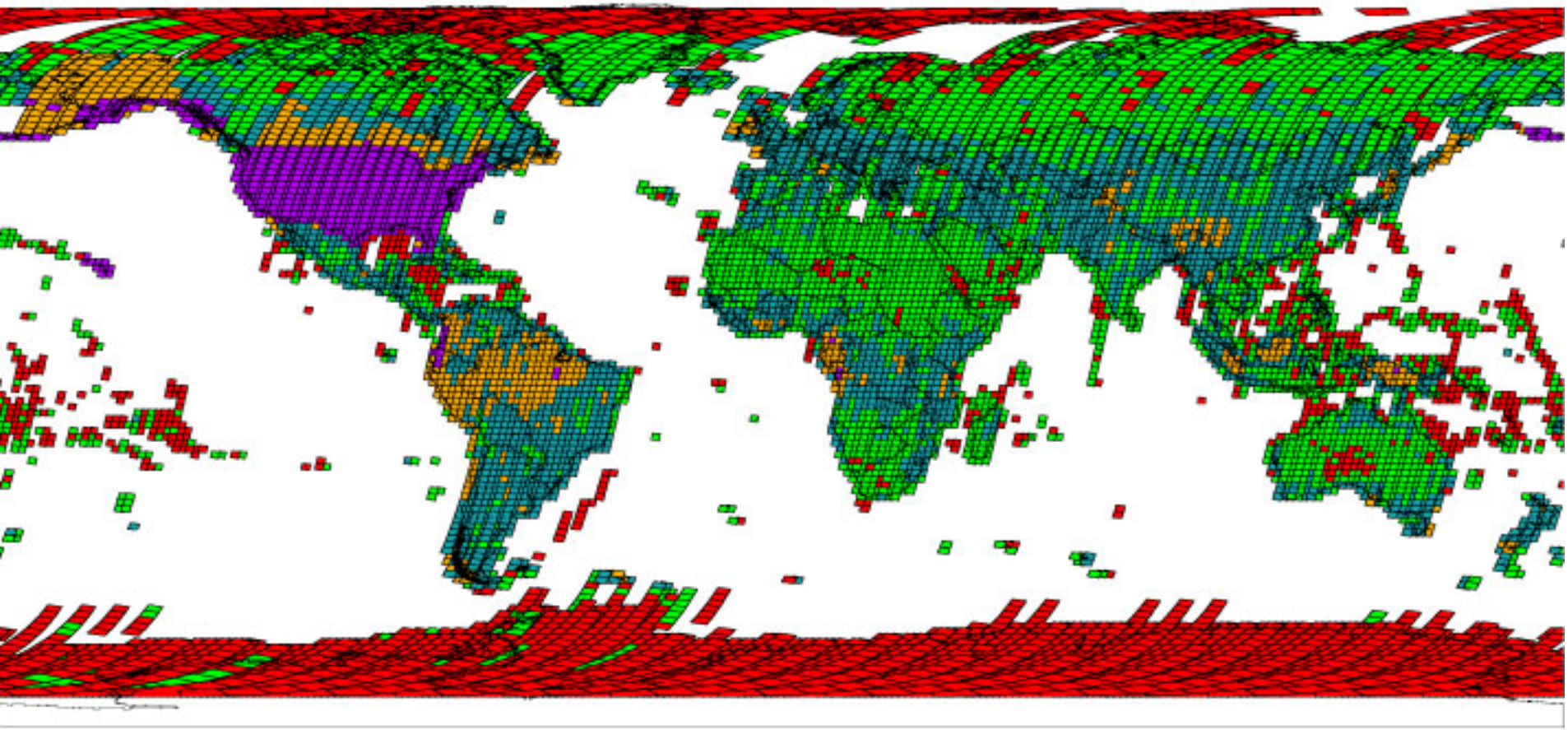
- Downlink
  - ~140 scenes per day to EDC
    - 40 per day of USA; 100 per day outside conterminous U.S.
  - ~110 per day to U.S. operated polar ground stations (PGS)
    - Poker Flat, Alaska
    - Svalbard, Norway
- Ingest and Archive
  - Scenes downloaded to EDC processed and archived within 24 hours
  - Scenes downloaded to PGS captured on tape and shipped to EDC

One Day's Acquisitions



9/27/2000

Data Archived through 3/31/2001



Acquisition Frequency (141,085 scenes) 06/28/1999 - 03/31/2001

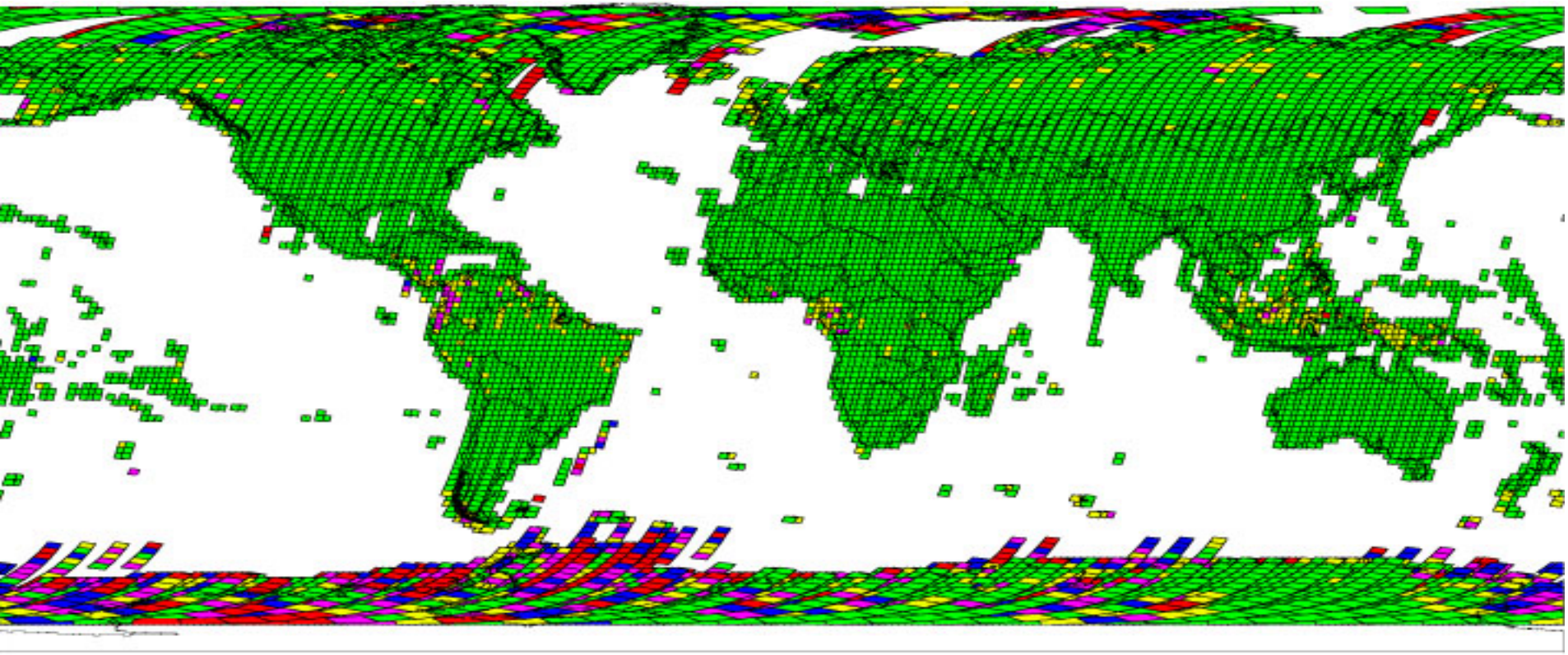
1-5 6 - 12 13 - 20 21 - 31 32 - 42

Landsat 7 data archived during the first 21 months of operation.

U.S. Department of the Interior
U.S. Geological Survey

Landsat 7 Program

Availability of Cloud Free Data

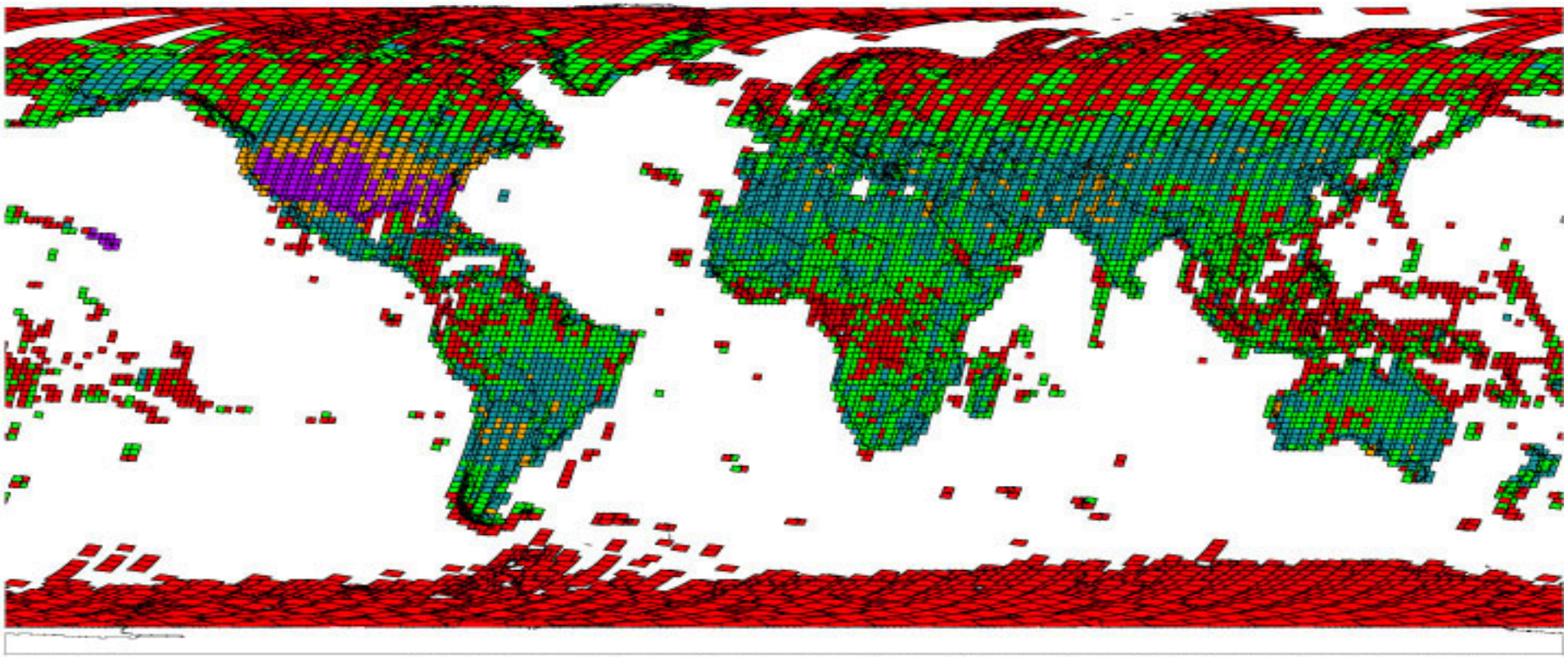


Cloud Cover

- 0% - 10%
- 11% - 25%
- 26% - 50%
- 51% - 75%
- 76% - 100%

This map shows the lowest available cloud cover for each of the 14,069 unique, daytime path/row combinations in the US Landsat 7 Archive. (June 28, 1999 - March 31, 2001)

Volume of Cloud Free Data

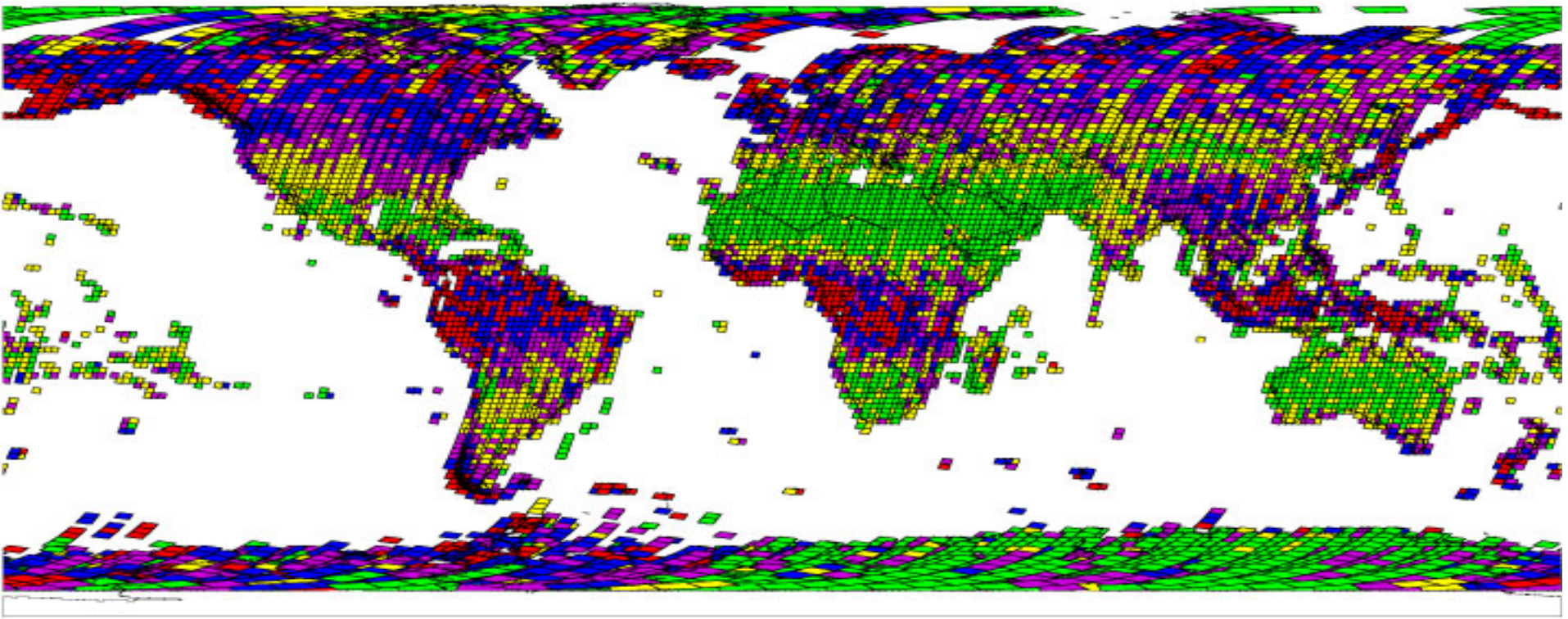


Cloud Cover

- 1 - 4
- 5 - 8
- 9 - 14
- 15 - 22
- 23 - 36

This map shows the number of scenes with 30% or less cloud cover in the US Landsat 7 archive.
12,498 unique, daytime path/row combinations
72,902 total scenes
June 28, 1999 - March 31, 2001

Success of Cloud Avoidance



Cloud Avoidance (%)

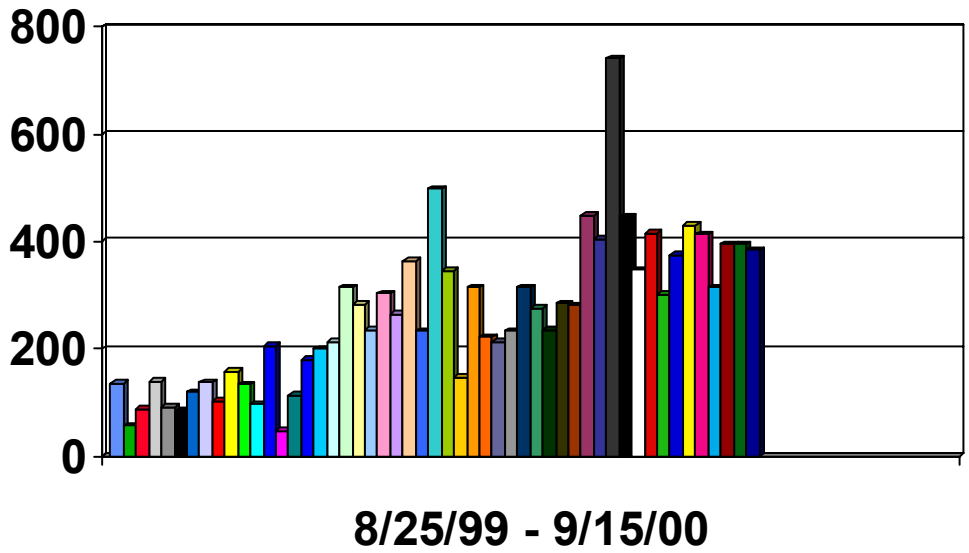
- 100 - 85
- 84 - 62
- 61 - 43
- 42 - 24
- 23 - 3

This map indicates the success of the cloud avoidance stratagey for the US Landsat 7 archive. The colors represent the percentage of all scenes collected that have a reported cloud cover of 30% or less.
12,498 unique, daytime path/row combinations
72,902 total scenes
June 28, 1999 - March 31, 2001

Product Generation/Distribution

Products Ordered per Week

FY2000

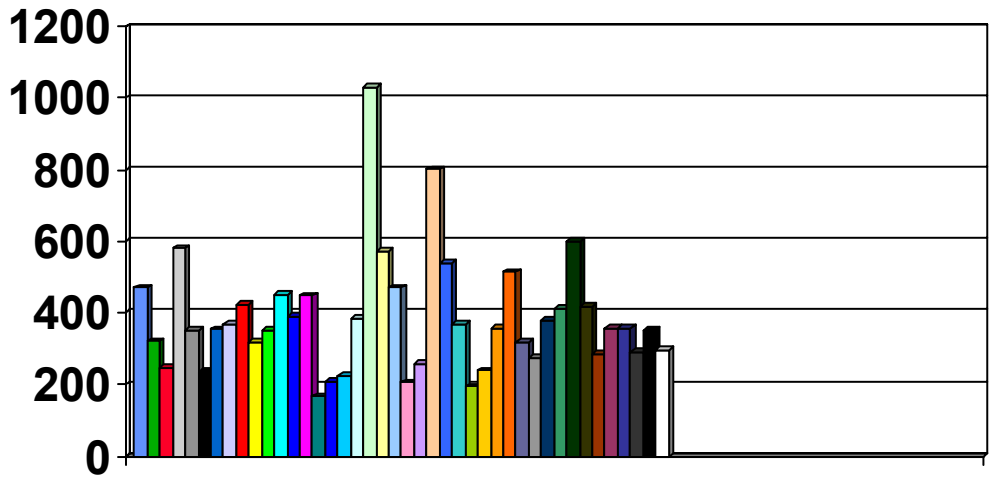


- ~52 products ordered per day (FY 2000)
  - 94% Level1

Product Generation/Distribution

Products Ordered per Week

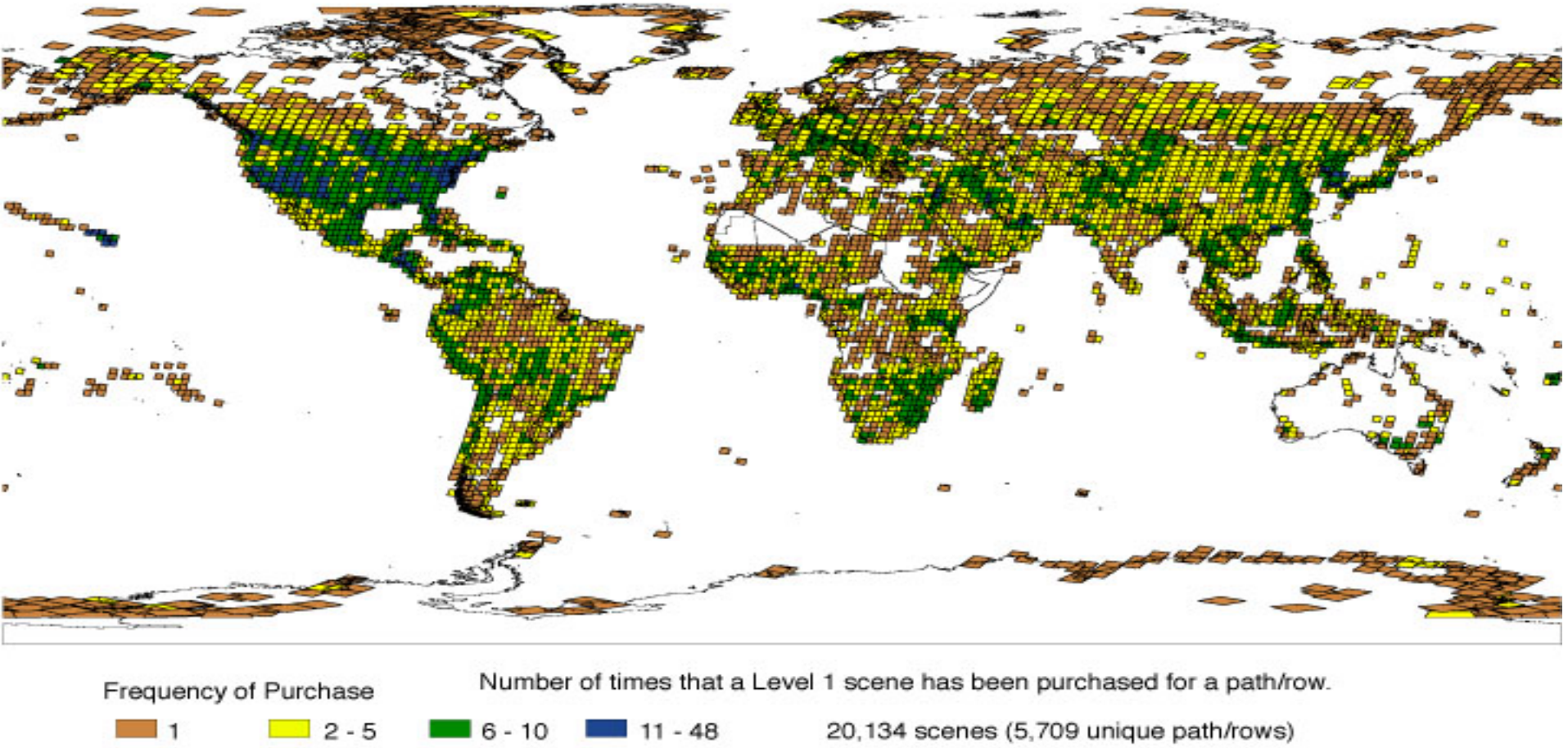
FY2001



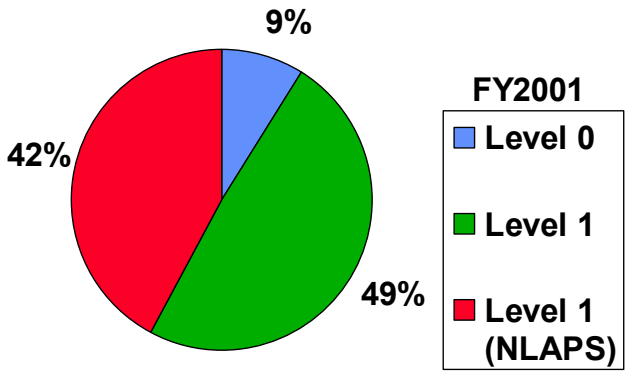
9/16/00 - 7/06/01

- ~77 products ordered per day (FY 2001)
  - 91% Level1

Purchases per Path/Row



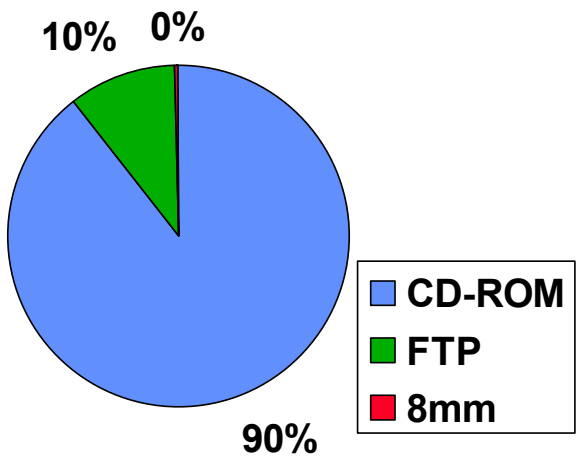
Levels, Media and Format



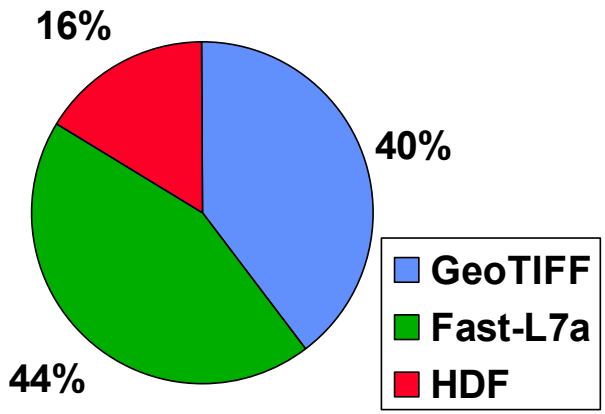
L0r - 1037

L1(LPGS) - 5678

L1(NLAPS) - 4883

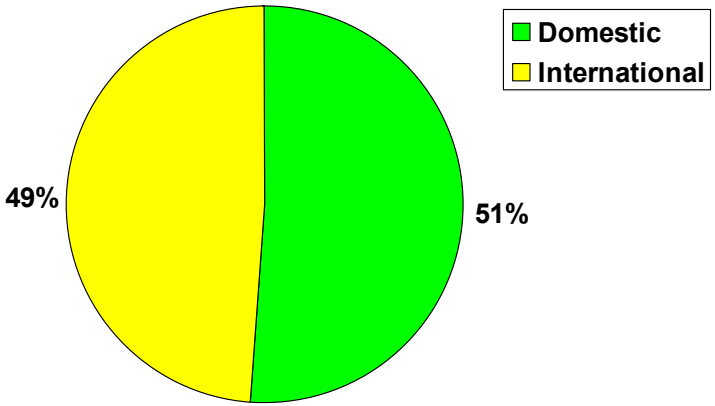


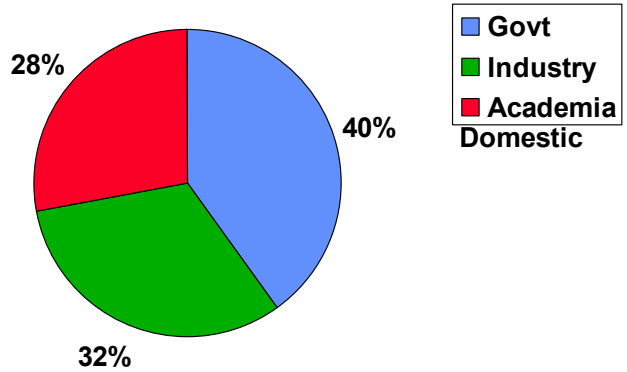
8mm - 21 units

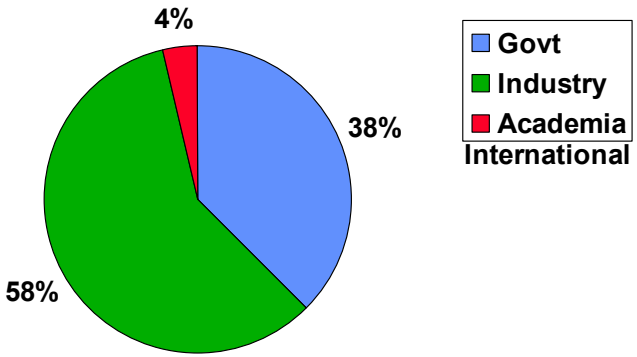


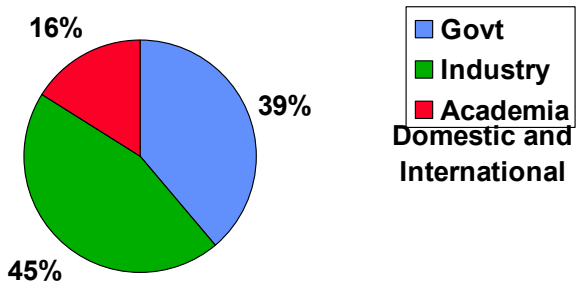
LPGS only - through April, 2001

Data Sales (FY 2001)









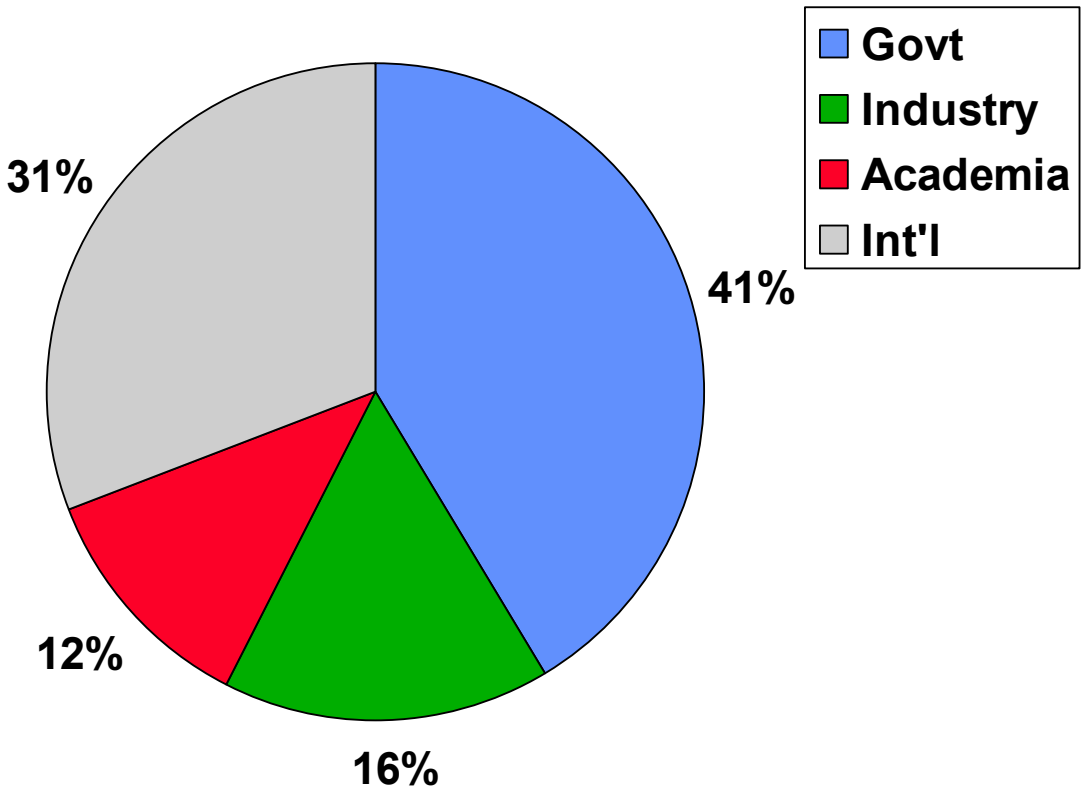
- FY 2000 data sales ~$6,431,410
- 10,850 scenes sold

FY2000 - 8/23/99 - 9/15/00

- FY 2001 data sales ~$ 6,998,253
- 14,042 scenes sold

FY20001 9/16/00 - 7/06/01

Data Sales Demographics FY 2000

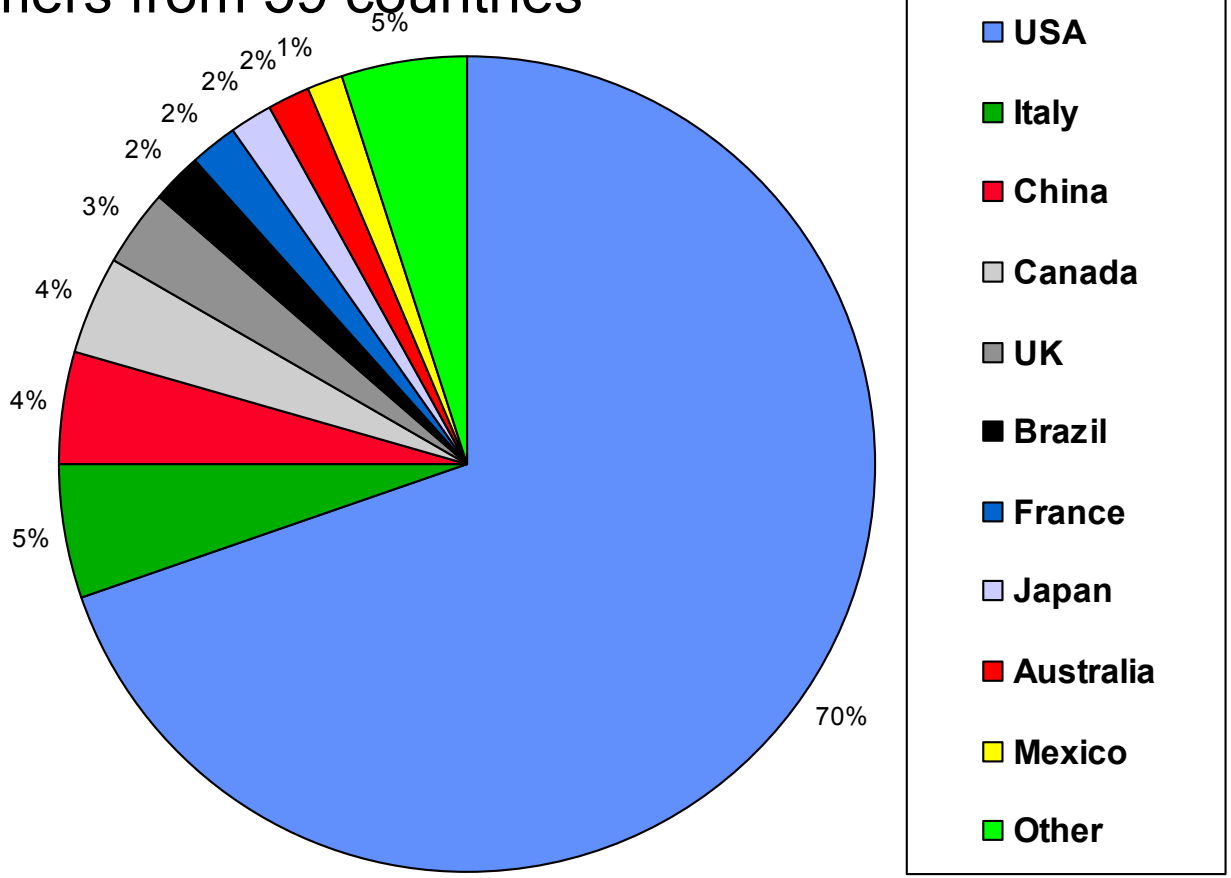


- 10,850 scenes sold
- FY 2000 data sales ~$6,431,410

FY 2000: 8/23/99 - 9/15/00

Customers Demographics FY 2000

- 1052 customers from 59 countries



FY 2000 - 8/23/99 - 9/15/00

Customers

Business Partners

Applied Analysis Incorporated	Billerica, Massachusetts
Bio Geo Recon	Sonora, California
Cooper Aerial Surveys Co.	Phoenix, Arizona
CSIR/Satellite Applications Centre	Pretoria, S.A.
Earth Imaging Center	Stennis Space Center, Miss
Earth Satellite Corporation	Rockville, Maryland
Earth Watch Inc.	Longmont, Colorado
East View Cartographic Inc.	Plymouth, Minnesota
EGS Technologies Corp.	Bloomingdale, Illinois
ENGESAT	Curitiba, Brazil
Eurimage S.P.A.	Rome, Italy
Forest One, Inc.	Evanston, Illinois
GEOID, Inc.	Trois Rivieres, Canada
Geosys, Inc.	Plymouth, Minnesota
GTT Net Corp.	Tampa, Florida
I-Cubed	Fort Collins, Colorado
Image Links, Inc.	Melbourne, Florida

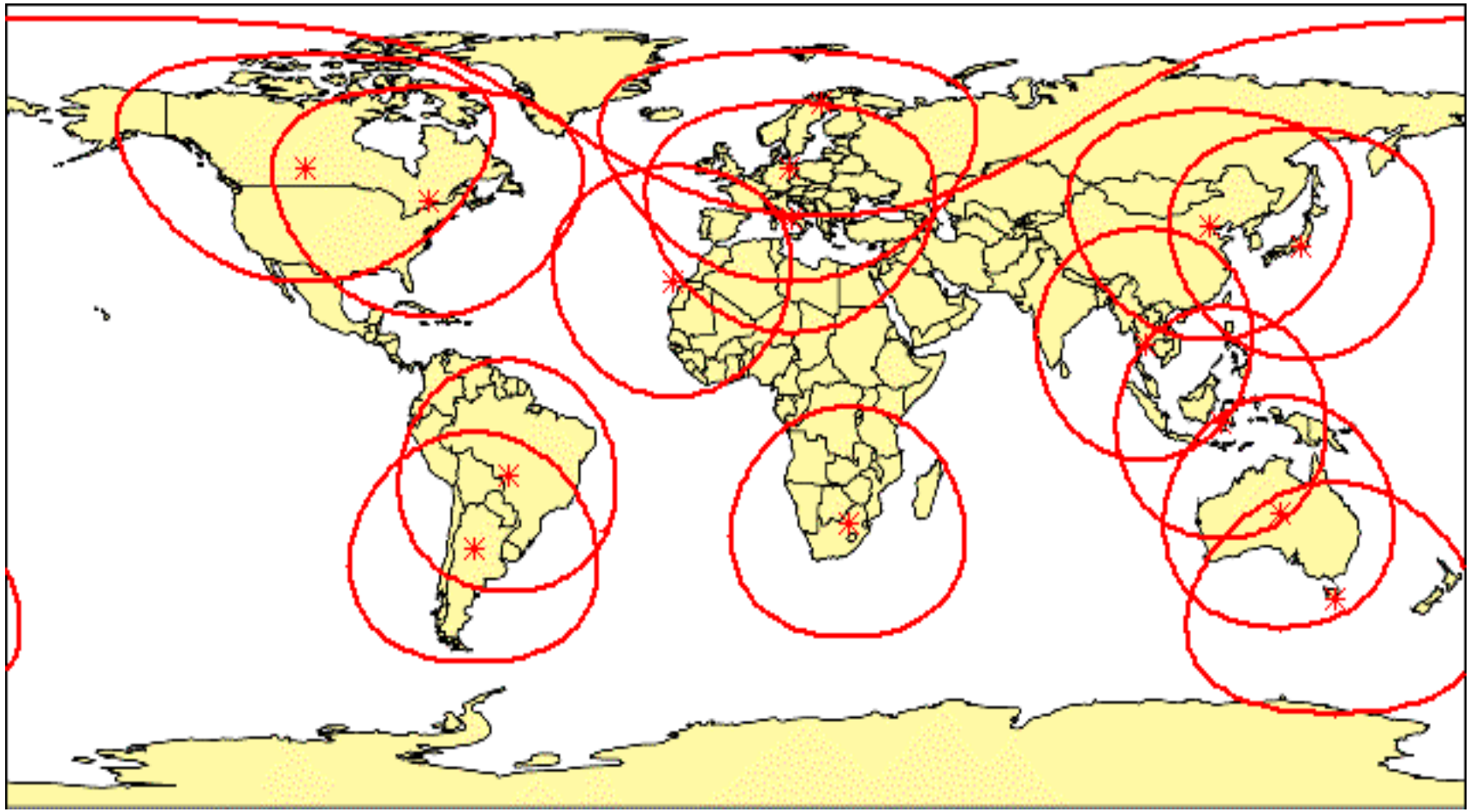
Customers

Business Partners

INGR Philippines Corporation	Makati City, Philippines
International Remote Imagery	Sioux Falls, South Dakota
Intersat Imagens de Satelite	Sao Jose Dos Campos, Brazil
ISTAR	Sophia Antipolis, France
National Remote Sensing Centre	Farnborough, United Kingdom
Natural Systems Analyst, Inc.	Winter Park, Florida
Pacific Geomatics Ltd.	Surrey, B.C., Canada
Prosis S.A.	Bogota, Columbia
Radarsat International	Richmond, Canada
Silvana Import Trading, Inc.	Montreal, Quebec, Canada
SPOT Image Corporation	Reston, Virginia
Telemorphic, Inc.	Oakland, California
Terra Space	Moscow, Russia
TMS Communications Ltd.	Kobe, Japan
Tobin International, Ltd.	San Antonio, Texas
Victor Torres	Washington, D.C.

http://mapping.usgs.gov/www/partners/bpfind.html

International Cooperator Network



International Ground Stations

Ten cooperators with 16 operational stations

- **Argentina**
  - COA - July 18, 1999
- **Australia**
  - ASA - July 6, 1999; HOA - July 14, 1999
- **Brazil**
  - CUB - November 10, 2000
- **Canada**
  - GNC - July 6, 1999; PAC - July 6, 1999
- **China**
  - BJC - March 1, 2000
- **ESA**
  - FUI - July 8, 1999; KIS/MPS - July 8, 1999/ December 14, 1999
  - NSG - July 15, 1999
- **Indonesia**
  - DKI - November 1, 2000
- **Japan**
  - HIJ/HAJ - March 1, 2000/May 1, 2000
- **Thailand**
  - BKT -Testing now
- **South Africa**
  - JSA - Testing now

Summary

- Successfully completed the first 24 months of mission operations
- Established an International Cooperator Network
- USGS has assumed responsibility for Landsat 7 spacecraft operations
- A Business Model has been established based on
  - SIR funding
  - International Cooperator fees
  - Data sales
- USGS has gained substantial national and international good will and credibility for managing the program and associated data policy

Landsat 7 Flight Operations Status (Spacecraft and MOC)

Landsat 7
Spacecraft and Ops Events

- 10/11/00 (Day 285) Delta-Inclination maneuver successfully completed, start time 13:52:40Z, duration 1172.3 seconds.
- 11/17/00 - 11/18/00 (Days 322, 323) Spacecraft passed through the Leonid storm without incident.
- 11/20/00 (Day 325) - “Lights Out” operations began.
- 12/25/00 (Day 360) - Spacecraft passed through the Moon’s shadow on two back-to-back orbits. Overall power balance and configuration was normal at the end of each orbit.
- 12/27/00 (Day 362) RTCS table in Flight Software was updated with new “end-o-year” RTCS values in preparation for 01/01/01.
- 12/31/00 (Day 366) - End of year operations completed successfully on SCP1.
- 01/10/01 (Day 10) End of year operations completed successfully on SCP2.

Landsat 7
Spacecraft and Ops Events (cont.)

02/09/01 (Day 040) - Added coordinates in FSW on both SCPs for DSN testing (Canberra).

02/11/01 (Day 042) to 02/13/01 - SSR PWA #12 anomaly and recovery . See anomaly section for details.

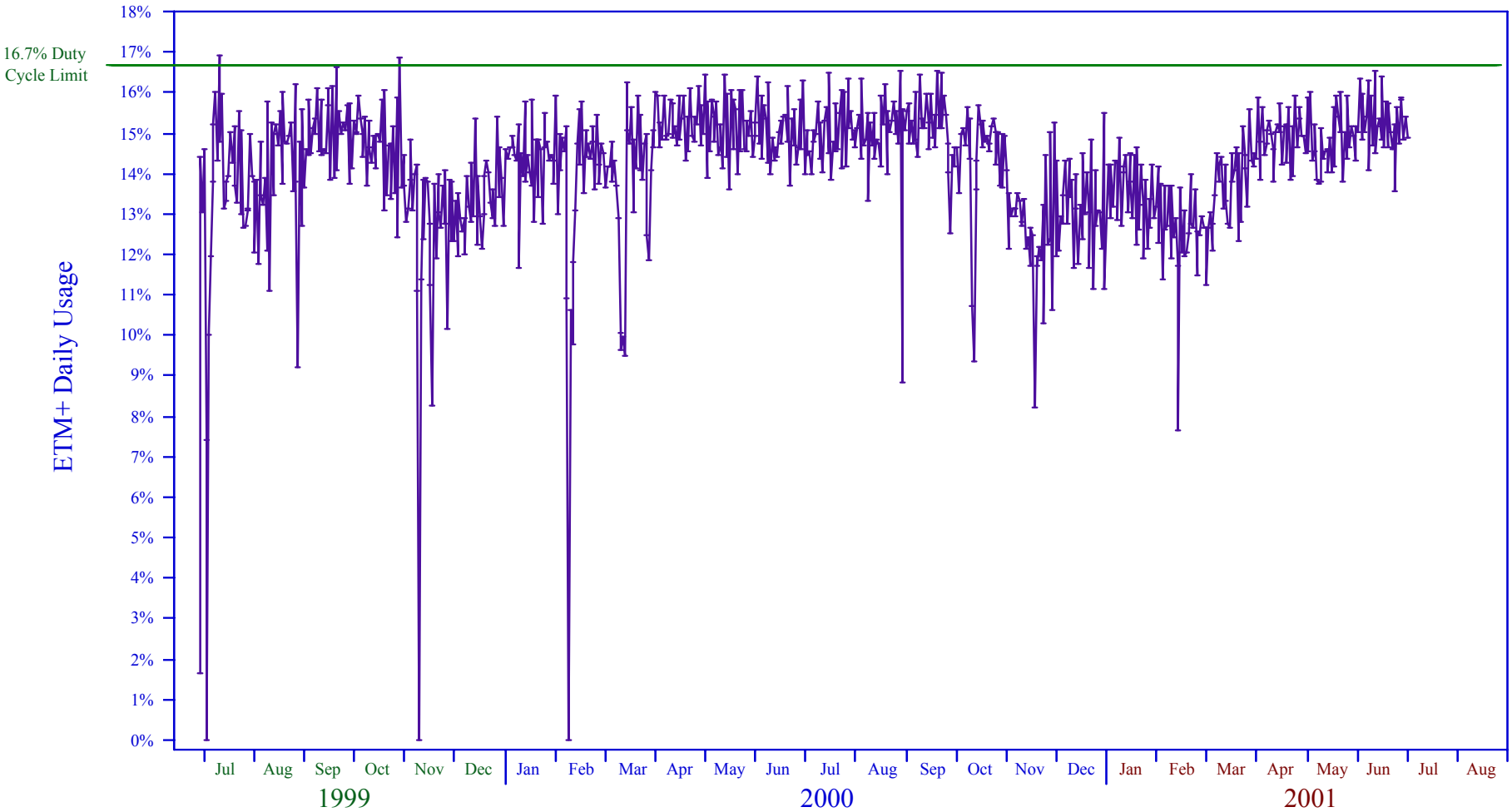
03/05/01 (Day 064) - CIU Buffer Busy" anomaly - no interruption to operations. See anomaly section for details.

04/10/01 (Day 100) - Changed the gyro channel used for Roll information in Backup ACS modes (GCYAW) from Xa to Xb.

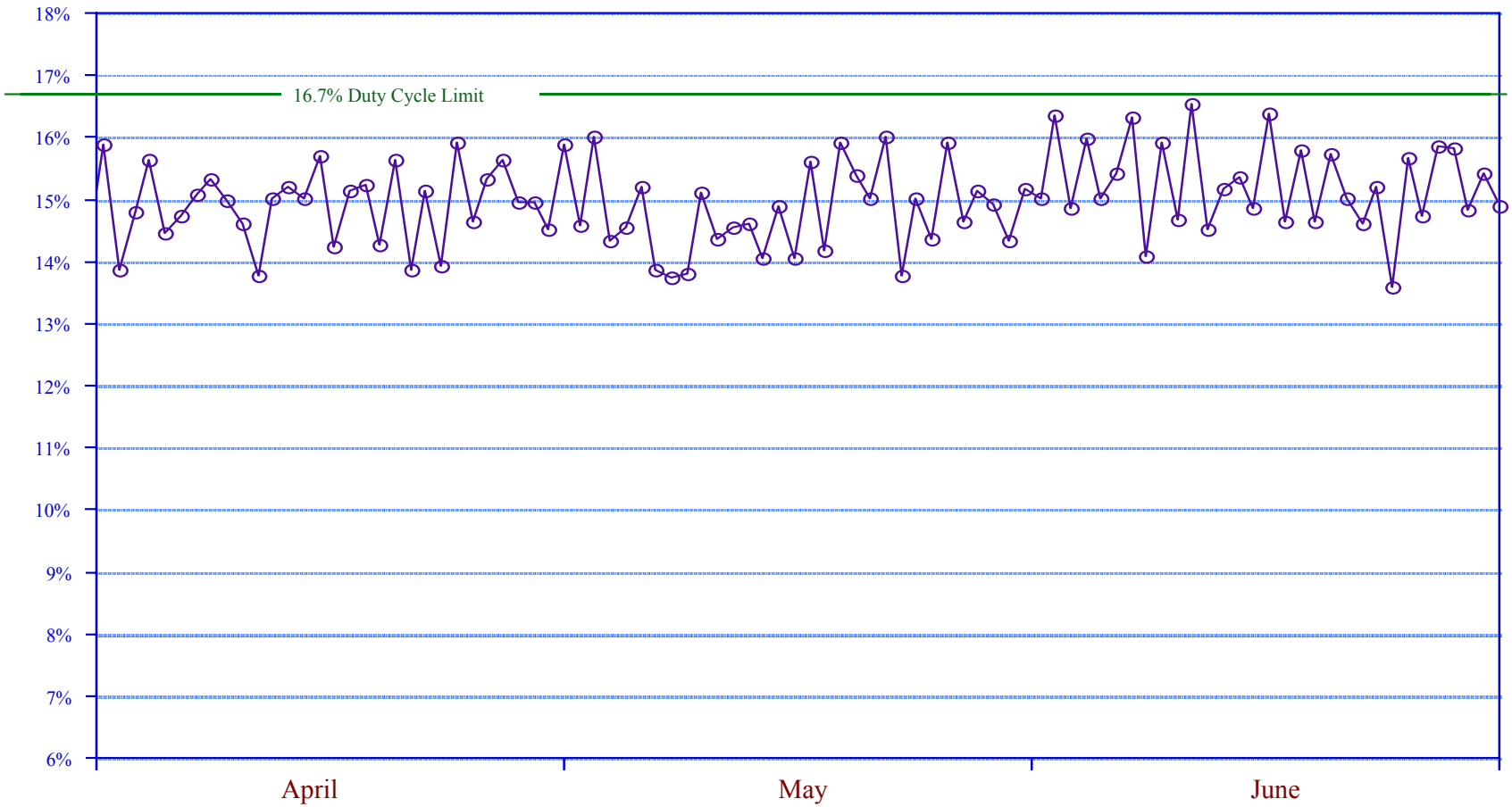
04/11/01 (Day 101) - Uplinked a patch to SSR RAM that will allow blocks to be "renamed" into areas that contain blocks that already "exist".

05/11/01 (Day 131) - Added coordinates in FSW on both SCPs for Matera, Italy

ETM+ Utilization : Lifetime Trend



ETM+ Utilization:April-June 2001



Landsat 7 Spacecraft Current Status

- Spacecraft Hardware and Software remains in the same configuration found at the end of the on-orbit checkout period except for the following:
  - Downlink site additions
  - RTCS updates
  - Time/year parameters
  - ESA Sun interference report timing
  - PRADS reset limit for unidentified stars
  - Celestial Star Sensor (CSA) alignment matrix
  - Maneuver abort limit due to attitude errors
  - SSR PWA #23 and #12 not in use
  - Gyro channel used for Roll data/control when in Backup modes switched from Xa to Xb
  - SSR RAM patches for hk dumps, TDF-SSR anomaly, and SSR-Rename anomaly

- Spacecraft orbit continues to meet specifications. To date, 45 orbit raising burns and 2 inclination raising burns have been completed.

- **Spacecraft performance and operation is nominal**. Mission objectives are being met and there are no indications of this changing in the near-term.

Landsat 7 Spacecraft Anomalies

02/11/01 (Day 042) - SSR PWA #12 shutdown without being commanded.

- -"Loss of modulation" reported by LGS operator. Investigation showed a failure of SSR PWA #12.
- 02/12/01 (Day 043) - Switched to "Realtime imaging" only.
- 02/13/01 (Day 044) - SSR PWA #12 removed from service. Normal operations resumed.

03/05/01 (Day 064) - CIU Buffer Busy.

- During loading of the daily stored command load, FSW calculated a different checksum for the load than the scheduling system. In addition, the "CIU Buffer Busy" condition was indicated by the spacecraft.
- Load was rebuilt (although original load was valid) and uplinked at next contact without incident. No interruption to operations.
- Investigation (including a dump of FSW before any more loads were uplinked) revealed that an extra 16 bits had been "inserted" into the command stream at the CIU/SCP interface. The CIU declared itself "busy" during a word transfer, and the SCP/FSW seemingly "double read" the previous word.
- Currently, no root cause can be found. Active investigation closed.

Landsat 7
On-Going Investigations/Efforts

The Flight Ops Team is working on several ongoing investigations/efforts...

SSR -

-Implementation of the second patch is complete. Operational testing is ongoing. Preliminary results are good.

-Generation of SSR PWA board activation procedures is underway.

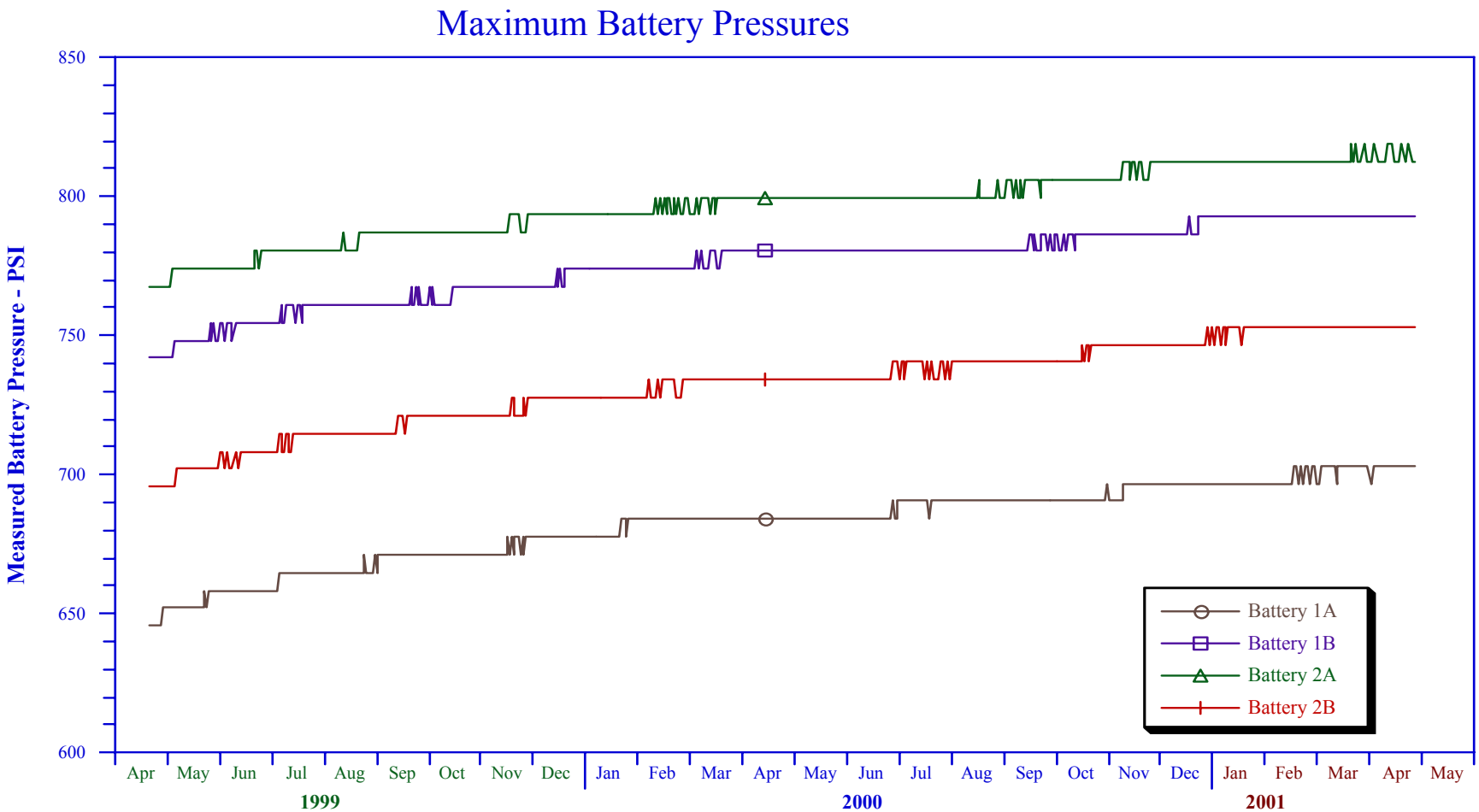
Battery Pressure - Procedures for possible use in lowering pressure (in an anomaly situation) are being generated. (see plot)

ETM+ Turn Around Time (TAT) - No change from last month. (see plot)

ETM+ duty cycle - Possible changes to LTAP may affect ETM+ use.

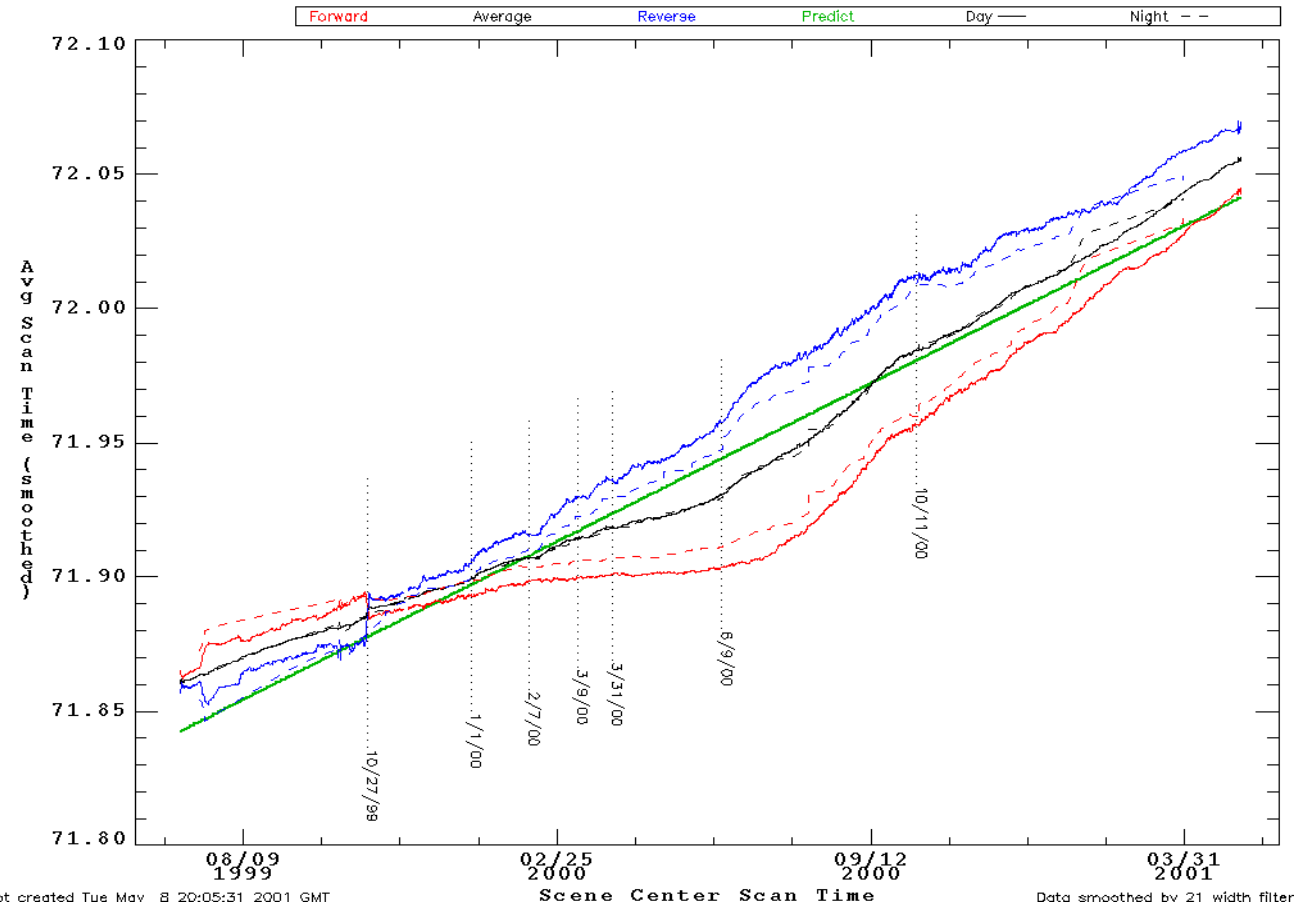
Investigation into gyro bias changes for Gyro #2 continues. Other users of this IMU package have been consulted. MGS and NOAA-15 reports being reviewed. Bias seems to be settling. (See plots)

Landsat 7
On-Going Investigations/Efforts



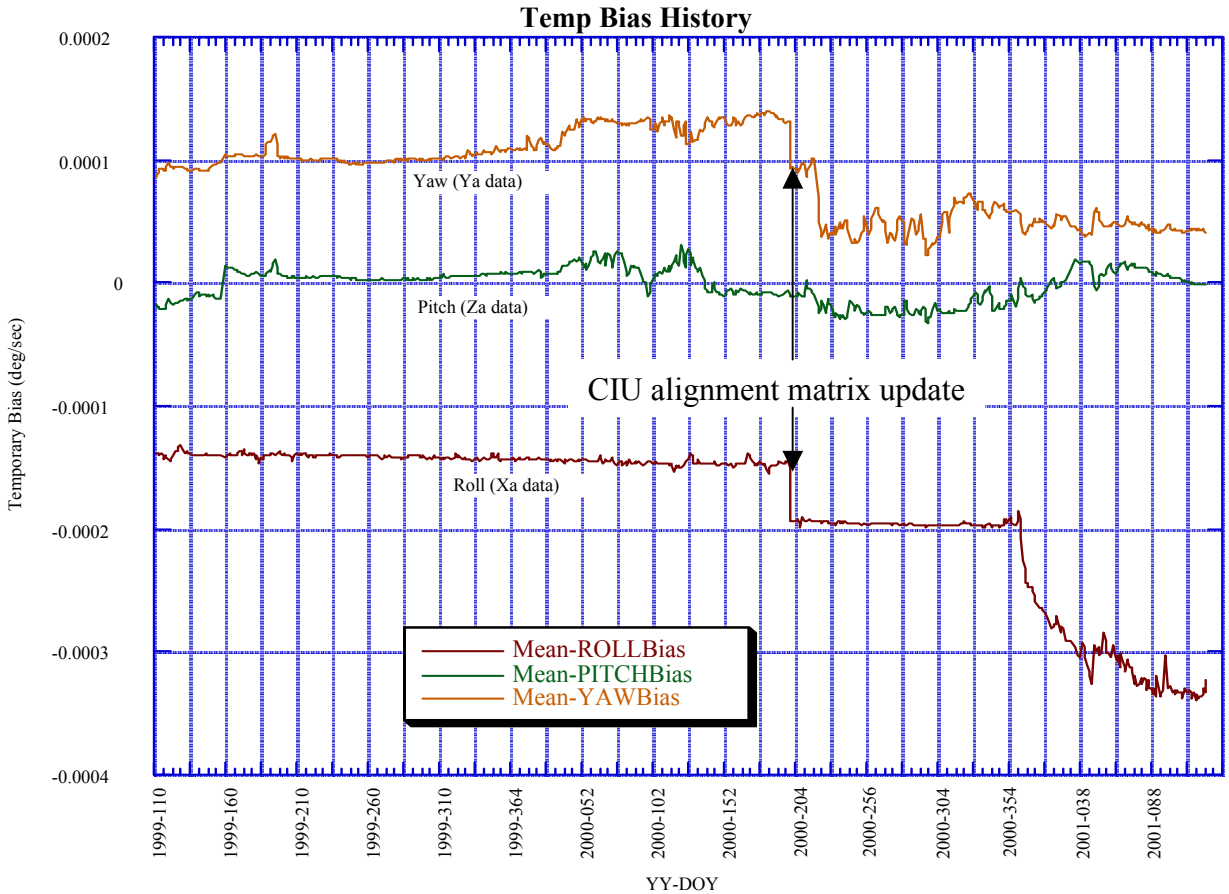
Landsat 7
On-Going Investigations/Efforts

ETM+ Scan Time (from IAS web site)



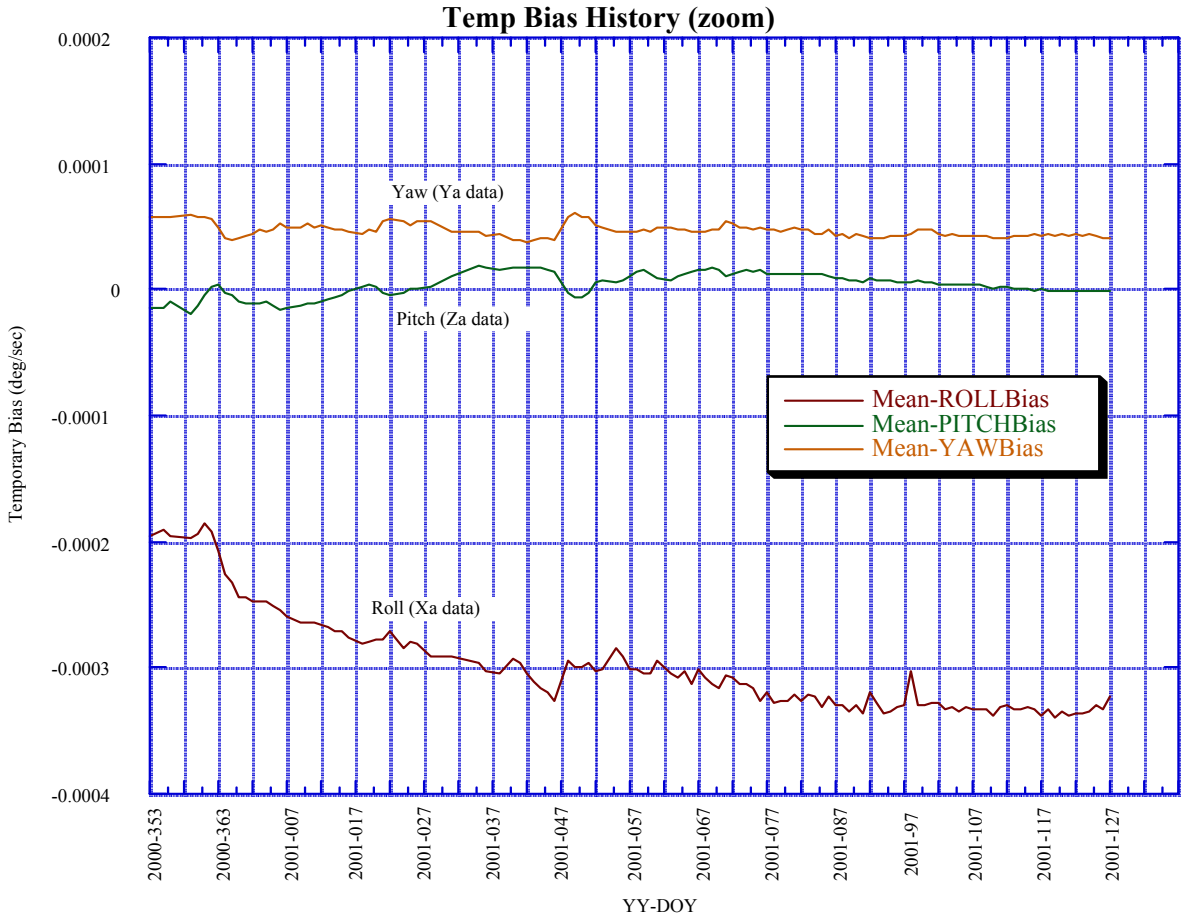
Landsat 7
On-Going Investigations/Efforts

Gyro Bias (for the three operational channels)

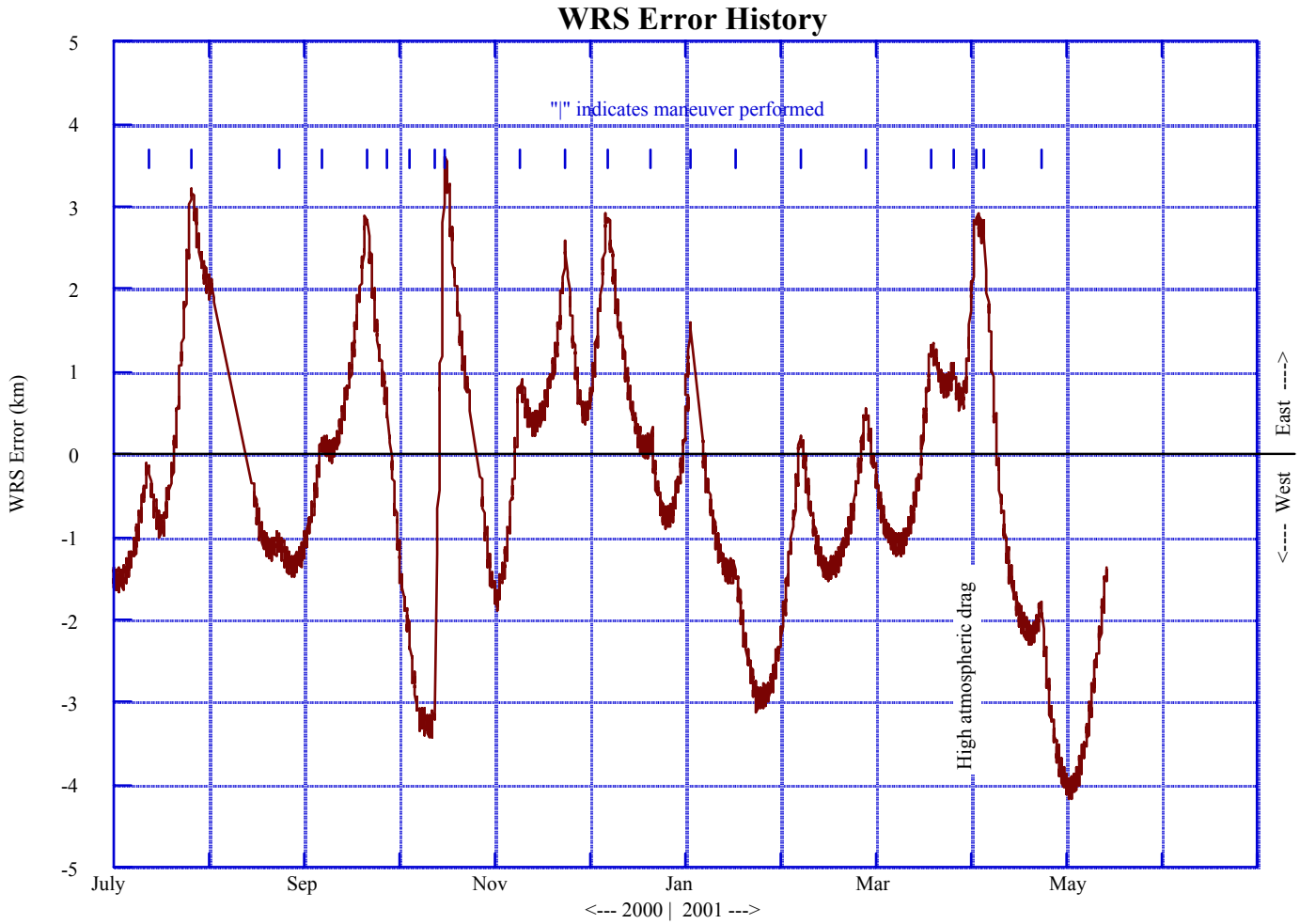


Landsat 7
On-Going Investigations/Efforts

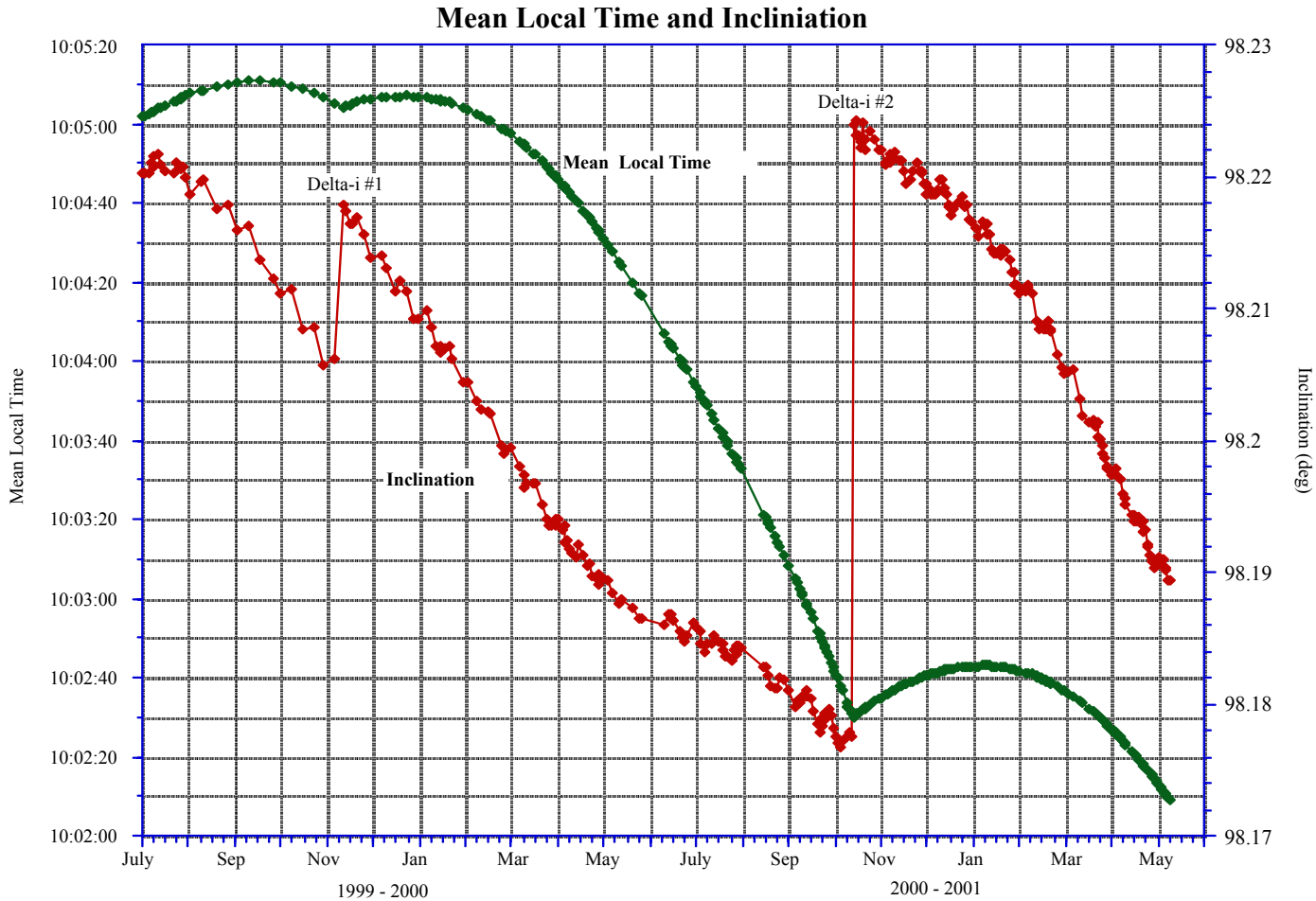
Gyro Bias (for the three operational channels)



Landsat 7
Orbit and Expendables



Landsat 7
Orbit and Expendables



MOC Status

MOC Status

- Current MOC Status…
  - MOC hardware and software are **Green** and able to support operations.

- Landsat 7 On-Orbit Flight Automation (LOOFA) Status (June)

107 automated passes scheduled during June 2001.

105 automated passes successfully completed.

2 automated passes not completed due to command problems at sites.

Selected System pages :

Most “pages” were generated in response to line outages between the MOC and ground site, and PTP or other connections problems at the sites.

Upcoming Activities (next 3 months)

- S/C
  - Begin planning for Delta-i #3
  - Dust off Leonid plan
- MOC
  - IPM web tool integration on IGS NT Server and interface to the MOC scheduling system
  - Version Manager (VM) testing